

How People Learn:

Brain, Mind, Experience, and School

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Executive Summary

Learning is a basic, adaptive function of humans. More than any other species, people are designed to be flexible learners and active agents in acquiring knowledge and skills. Much of what people learn occurs without formal instruction, but highly systematic and organized information systems--reading, mathematics, the sciences, literature, and the history of a society--require formal training, usually in schools. Over time, science, mathematics, and history have posed new problems for learning because of their growing volume and increasing complexity. The value of the knowledge taught in school also began to be examined for its applicability to situations outside school.

Science now offers new conceptions of the learning process and the development of competent performance. Recent research provides a deep understanding of complex reasoning and performance on problem-solving tasks and how skill and understanding in key subjects are acquired. This book presents a contemporary account of principles of learning, and this summary provides an overview of the new science of learning.

FIVE THEMES THAT CHANGED CONCEPTIONS OF LEARNING

In the last 30 years, research has generated new conceptions of learning in five areas. As a result of the accumulation of new kinds of information about human learning, views of how effective learning proceeds have shifted from the benefits of diligent drill and practice to focus on students' understanding and application of knowledge.

1. ***Memory and structure of knowledge*** Memory has come to be understood as more than simple associations; evidence describes the structures that represent knowledge and meaning. Knowing how learners develop coherent structures of information has been particularly useful in understanding the nature of organized knowledge that underlies effective comprehension and thinking.

2. ***Analysis of problem solving and reasoning*** One of the most important influences on contemporary learning theory has been the basic research on expert learners. Learning theory can now account for how learners acquire skills to search a problem space and then use these general strategies in many problem-solving situations. There is a clear distinction between learned problem-solving skills in novice learners and the specialized expertise of individuals who have proficiency in particular subjects.

3. ***Early foundations*** The development of creative methodologies for assessing infants' responses in controlled research settings has done much to illuminate early learning. Scientific studies of infants and young children have revealed the relationships between children's learning predispositions and their emergent abilities to organize and coordinate information, make inferences, and discover strategies for problem solving. As a result, educators are rethinking the role of the skills and abilities children bring with them to school to take advantage of opportunities for learning in school.

4. ***Metacognitive processes and self-regulatory capabilities*** Individuals can

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be taught to regulate their behaviors, and these regulatory activities enable self-monitoring and executive control of one's performance. The activities include such strategies as predicting outcomes, planning ahead, apportioning one's time, explaining to one's self in order to improve understanding, noting failures to comprehend, and activating background knowledge.

5. *Cultural experience and community participation* Participation in social practice is a fundamental form of learning. Learning involves becoming attuned to the constraints and resources, the limits and possibilities, that are involved in the practices of the community. Learning is promoted by social norms that value the search for understanding. Early learning is assisted by the supportive context of the family and the social environment, through the kinds of activities in which adults engage with children. These activities have the effect of providing to toddlers the structure and interpretation of the culture's norms and rules, and these processes occur long before children enter school.

EXPERT PERFORMANCE

By definition, experts have developed particular ways to think and reason effectively. Understanding expertise is important because it provides insights into the nature of thinking and problem solving. It is not simply general abilities, such as memory or intelligence, nor the use of general strategies that differentiate experts from novices. Instead, experts have acquired extensive knowledge that affects what they notice and how they organize, represent, and interpret information in their environments. This, in turn, affects their abilities to remember, reason, and solve problems.

Key scientific findings have come from studies of people who have developed expertise in areas such as chess, physics, mathematics, electronics, and history. The examples are important *not* because all school children are expected to become experts in these or any other areas, but because the study of expertise shows what the results of successful learning look like.

Key conclusions:

- Experts notice features and meaningful patterns of information that are not noticed by novices.
- Experts have acquired a great deal of content knowledge that is organized, and their organization of information reflects a deep understanding of the subject matter.
- Experts' knowledge cannot be reduced to sets of isolated facts or propositions but, instead, reflects contexts of applicability, i.e., it is "conditionalized."
- Experts are able to retrieve important aspects of their knowledge with little attentional effort.
- Though experts know their disciplines thoroughly, this does not guarantee that they are able to instruct others about the topic.
- Experts have varying levels of flexibility in their approaches to new situations.

TRANSFER OF LEARNING

Another aspect of *effective* learning is its durability--does the learning have long-term impact in the ways it influences other kinds of learning or performance? Research studies on the concept of transfer of learning comprise a vast literature that can be synthesized into the new science of learning.

Key conclusions:

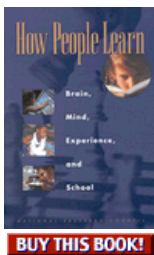
- Skills and knowledge must be extended beyond the narrow contexts in which they are initially learned. For example, knowing how to solve a math problem in school may not transfer to solving math problems in other contexts.
- It is essential for a learner to develop a sense of *when* what has been learned can be used--the conditions of application. Failure to transfer is often due to learners' lack of this type of conditional knowledge.
- Learning must be guided by generalized principles in order to be widely applicable. Knowledge learned at the level of rote memory rarely transfers; transfer most likely occurs when the learner knows and understands underlying principles that can be applied to problems in new contexts.
- Learners are helped in their independent learning attempts if they have conceptual knowledge. Studies of children's concept formation and conceptual development show the role of learners' mental representations of problems, including how one problem is similar *and* different from others and understanding the part-whole relationships of the components in the overall structure of a problem.
- Learners are most successful if they are mindful of themselves as learners and thinkers. A learner's self-awareness as a learner and the role of appraisal strategies keep learning on target or help keep the learner asking if s/he understands. Learners can become independent learners who are capable of sustaining their own learning--in essence, this is how human beings become life-long learners.

CHILDREN AS LEARNERS

While there are remarkable commonalities across learners of all ages, children differ from adult learners in many ways. Studies of young children offer a window into the development of learning, and they show a dynamic picture of learning as it unfolds over time. A fresh understanding of infant cognition and of how young children build on early learning predispositions also offers ideas on ways to ease their transition into formal school settings.

Key findings:

- Humans have a predisposition to learn in certain domains, and young children actively engage in making sense of their worlds. In particular domains, such as biological and physical causality, number, and language, infants and young children have strong predispositions to learn rapidly and readily. These biases toward learning support and may make early learning possible and pave the way for competence in early schooling.
- Children lack knowledge and experience, but not reasoning ability. Although young children are inexperienced, they reason facilely with the knowledge they have.
- Precocious knowledge may jump-start the learning process, but because of limited experience and undeveloped systems for logical thinking, children's



knowledge contains misconceptions. Misinformation can impede school learning, so teachers need to be aware of the ways in which children's background knowledge influences what they understand. Such awareness on the part of teachers will help them anticipate children's confusion and recognize why the children have difficulties grasping new ideas.

- Strategies for learning are important. Children can learn practically anything by sheer will and effort, but when required to learn about non-privileged domains, they need to develop strategies of intentional learning.
- Children need to understand what it means to learn, who they are as learners, and how to go about planning, monitoring, and revising, to reflect upon their learning and that of others, and to learn to determine for themselves if they understand. These skills of metacognition provide strategic competencies for learning.
- Children are both problem solvers and problem generators. They attempt to solve problems presented to them, and they seek novel challenges. They refine and improve their problem-solving strategies in the face of failure and often build on prior successes. They persist because success and understanding are motivating in their own right.
- Adults help children make connections between new situations and familiar ones. Children's curiosity and persistence are supported by adults who direct children's attention, structure experiences, support learning attempts, and regulate the complexity and difficulty levels of information for children.

Children, thus, exhibit capacities that are shaped by environmental experiences and the individuals who care for them. Developmental processes involve interactions between children's early competencies and the environmental supports--strengthening relevant capacities and pruning the early abilities that are less relevant to the child's community. Learning is promoted and regulated by both the biology and ecology of the child; learning *produces* development.

COLLATERAL DEVELOPMENT OF MIND AND BRAIN

Advances in neuroscience are confirming many theoretical hypotheses, including the important role of early experience in development. What is new, and therefore important for a new science of learning, is the *convergence* of evidence from a number of scientific fields. As developmental psychology, cognitive psychology, and neuroscience, to name but three, have contributed vast numbers of research studies, details about learning and development have converged to form a more complete picture of how intellectual development occurs. Clarification of some of the mechanisms of learning by neuroscience advanced with the advent of non-invasive imaging technologies, such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). These technologies enabled researchers to observe directly functions of human learning.

The key finding is the importance of experience in building the structure of the mind by modifying the structures of the brain: development is not solely the unfolding of preprogrammed patterns. Some of the rules that govern learning are now known. One of the simplest rules is that practice increases learning and there is a corresponding relationship between the amount of experience in a complex environment and the amount of structural change in the brain.

Key conclusions:

- Learning changes the physical structure of the brain.

- Structural changes alter the functional organization of the brain; in other words, learning organizes and reorganizes the brain.
- Different parts of the brain may be ready to learn at different times.

DESIGNS FOR LEARNING ENVIRONMENTS

Theoretical physics does not prescribe the design of a bridge, but surely it constrains the design of successful ones. Similarly, learning theory provides no simple recipe for designing effective learning environments, but it constrains the design of effective ones. New research raises important questions about the design of learning environments—questions that suggest the value of rethinking what is taught, how it is taught, and how it is assessed.

A fundamental tenet of modern learning theory is that different kinds of learning goals require different approaches to instruction; new goals for education require changes in opportunities to learn. The design of learning environments is linked to issues that are especially important in the processes of learning, transfer, and competent performance. Those processes, in turn, are affected by the degree to which learning environments are student centered, knowledge centered, assessment centered, and community centered.

Key conclusions:

- ***Learner-centered environments*** Effective instruction begins with what learners bring to the setting; this includes cultural practices and beliefs, as well as knowledge of academic content. A focus on the degree to which environments are learner centered is consistent with the evidence showing that learners use their current knowledge to construct new knowledge and that what they know and believe at the moment affects how they interpret new information. Sometimes learners' current knowledge supports new learning; sometimes it hampers learning.

People may have acquired knowledge yet fail to activate it in a particular setting. Learner-centered environments attempt to help students make connections between their previous knowledge and their current academic tasks. Parents are especially good at helping their children make connections. Teachers have a harder time because they do not share the life experiences of all of their students, so they have to become familiar with each student's special interests and strengths.

- ***Knowledge-centered environments*** The ability to think and solve problems requires knowledge that is accessible and applied appropriately. An emphasis on knowledge-centered instruction raises a number of questions, such as the degree to which instruction focuses on ways to help students use their current knowledge and skills. New knowledge about early learning suggests that young students are capable of grasping more complex concepts than was believed previously. However, these concepts must be presented in ways that are developmentally appropriate by linking learning to their current understanding. A knowledge-centered perspective on learning environments highlights the importance of thinking about designs for curricula. To what extent do they help students learn with understanding versus promote the acquisition of disconnected sets of facts and skills? Curricula that are a "mile wide and an inch deep" run the risk of developing disconnected rather than connected knowledge.
- ***Assessment to support learning*** Issues of assessment also represent an important perspective for viewing the design of learning environments. Feedback is fundamental to learning, but feedback opportunities are often

scarce in classrooms. Students may receive grades on tests and essays, but these are summative assessments that occur at the end of projects. What are needed are formative assessments, which provide students with opportunities to revise and improve the quality of their thinking and understanding. Assessments must reflect the learning goals that define various environments. If the goal is to enhance understanding and applicability of knowledge, it is not sufficient to provide assessments that focus primarily on memory for facts and formulas.

- ***Community-centered environments*** The fourth, important perspective on learning environments is the degree to which they promote a sense of community. Students, teachers, and other interested participants share norms that value learning and high standards. Norms such as these increase people's opportunities and motivation to interact, receive feedback, and learn. The importance of connected communities becomes clear when one examines the relatively small amount of time spent in school compared to other settings. Activities in homes, community centers, and after-school clubs can have important effects on students' academic achievement.

EFFECTIVE TEACHING

Expertise of any kind involves more than a set of general problem-solving skills; it also requires well-organized knowledge of concepts and inquiry procedures. Various disciplines are organized differently and have their own methods of inquiry. For example, the evidence needed to support a set of historical claims is different from the evidence needed to prove a mathematical conjecture, and both of these differ from the evidence needed to test a scientific theory.

Key conclusions:

- Effective teachers need "pedagogical content knowledge"--knowledge about how to teach in particular disciplines, which is different from knowledge of general teaching methods.
- Expert teachers know the structure of their disciplines and this provides them with cognitive roadmaps that guide the assignments they give students, the assessments they use to gauge student progress, and the questions they ask in the give and take of classroom life.

In short, teachers' knowledge of the discipline and their knowledge of pedagogy interact. But knowledge of the discipline structure does not in itself guide a teacher. Expert teachers are sensitive to those aspects of the discipline that are especially hard and easy for new students to master. An emphasis on interactions between disciplinary knowledge and pedagogical knowledge directly contradicts a common misconception about what teachers need to know in order to design effective learning environments for their students. The misconception is that teaching consists only of a set of general methods, that a good teacher can teach any subject, and that content knowledge alone is sufficient.

Teacher learning is relatively new as a research topic, so there is limited information about it. Nevertheless, the research that exists, generally in the form of rich case studies, provides important information about what kinds of learning opportunities teachers need in order to change their practices.

Key findings:

- Opportunities for teachers to continue their learning fall short when viewed from the perspective of being learner, knowledge, assessment, and community centered. Preservice programs often fail to provide the kinds of